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# A QUANTITATIVE AND SEASONAL STUDY OF A PINE-DUNE ANIMAL COMMUNITY[1]

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## Introduction

Numerous studies of the quantity of life in water have been made; the quantity at different levels, at different hours of the day, etc., has been determined. Very little work of this character has been done on land. McAtee, Wolcott, and Beebe have covered grassland and forest floor, but we know of no attempt to estimate the entire animal population in a tree-covered area.

In addition to the quantitative problems a number of questions relative to the movements of animals arise. Do animals migrate back and forth from one plant community to another? When temperature and moisture conditions within a given plant community change radically, do animals shift from one zone or stratum to another? In other words, are there horizontal and vertical migrations? Or will animals found in the shrubs remain there throughout the day irrespective of changes of conditions? Animals free to shift back and forth are a much more sensitive index than plants.

## Locality and Methods

The observations here reported were made chiefly during the summer of 1914 in a pine hollow in the dune region at the south end of Lake Michigan (figs. 1, 2, 3). This hollow was situated between advancing dunes on the north and west, and an undrained reed and sedge marsh on the south, cut off from the Grand Calumet River by several large dunes. To the east lay an expanse of low dunes.

The chief tree of the station was Jack pine, *Pinus banksiana*. Other vegetation included willow, *Salix glaucophylla;* bearberry, *Arctostaphylos uva-ursi;* common juniper, *Juniperus communis;* poison sumach, *Rhus toxicodendron;* choke cherry, *Prunus Virginiana;* red-osier dogwood, *Cornus stolonifera;* horse mint, *Monarda punctata,* etc. The ground was partly open, the soil a light sandy loam. Near the margin the vegetation changed abruptly to sedges and swamp grasses which extended out into the open water of a shallow pond about two hundred feet in diameter. The work was confined entirely to a study of quantity and of the correlation of local, especially vertical, animal distribution with temperature and evaporation. Collections were made and temperature and evaporation recorded in each of the levels commonly recognized, viz., ground, herbs, shrubs, and trees, between July 1 and

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[1] Contribution from the Zoological Laboratory of the University of Chicago and from the Zoological Laboratory of the University of Illinois.

Fig. 1

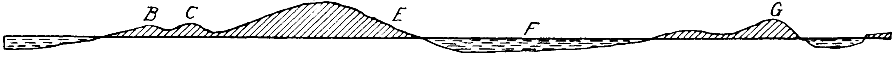


Fig. 2

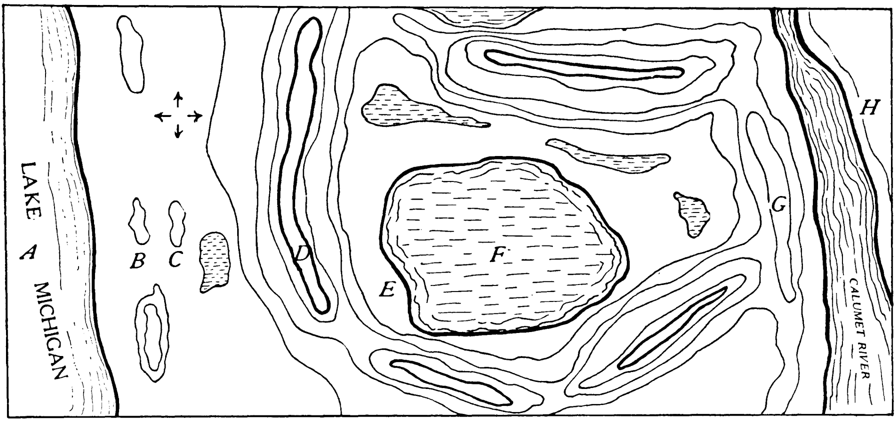
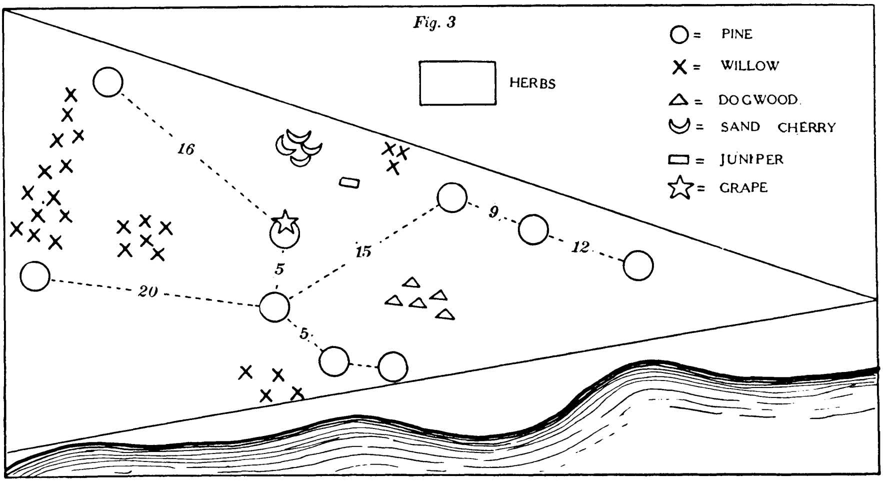


Fig. 3



FIGS. 1, 2, and 3. 1. Cross section of the area studied.

2. Map of environs of the plot studied: *A*, Lake Michigan; *B*, sand cherry and sand-binding grass; *C*, cottonwood dunes; *D*, young cottonwood forest starting at lake level; *E*, pine hollow; *F*, swamp of sedges, rushes, and open water; between *G* and *H*, Grand Calumet River; *H*, oak woods on old dunes. Scales of figs. 1 and 2 about 200 feet to the inch.

3. Detailed map of the area of study. Numbers indicate distance in feet between trees and shrubs.

August 30. This was done regularly every four or five days from all the levels at about 8:30 A.M. In addition, during two full days, the observations and collections were made in the various levels at intervals of four hours between 4:30 A.M. and 8:30 P.M. All of the specimens collected during one of these days were sent to specialists for identification to discover whether upward or downward migration takes place as the temperature or evaporation rate changes during the day. Dr. Charles A. Hart and J. R. Malloch, of the State Entomologist's Office at Urbana, and Mr. Nathan Banks, of East Falls Church, Virginia, identified the specimens. Dr. C. P. Alexander kindly assisted with the lists. The specimens taken the other days were used for quantitative comparison only.

The ground collections were made where there were only scattered short-stemmed herbs. An actual count was made by forcing the open end of a bucket 25 cm. (10 in.) in diameter into the soil. By pouring a small quantity of a mixture of chloroform and gasoline through an opening in the inverted bottom, all the animals on the ground under the bucket were killed. It was difficult to see small insects such as aphids in the light soil. By using a fine sieve it was possible to obtain many which otherwise would have escaped observation. The other collections were obtained by making four strokes at each level with a close cotton net on a ring 30 cm. in diameter, with a handle 70 cm. long. To reduce the collections made with the bucket and net to the same value, sweeping with the net was followed in the same type of vegetation by bucket counting. It was found with a number of trials that *three* sweeps of the net yield essentially the same number of animals from the vegetation as one bucket counting. Three strokes with the net equal approximately .022 cubic meter of average denseness; four strokes equal .029 cubic meter.

## Space Inhabitable[2]

The plot was the approximate equivalent of a rectangle eleven meters (35 ft.) by fourteen meters (45 ft.), or an area of one hundred fifty-four square meters (1,575 sq. ft.).

### *a.* HERB COVER

Herbs covered two thirds of the area, and one third was bare. The average cover was forty-five cm. (18 in.) in height. The herb cover, if uniformly distributed over the area, was 30 cm. or one foot deep.

### *b.* SHRUB COVER

A typical willow, with branches and leaves, is one meter (3 ft.) in diameter and 1.25 meters (4 ft.) tall. The general form approaches that of a sphere. The space occupied by each was .7 cu. m. (24.4 cu. ft.), and for twenty-six the space was 18.2 cu. m. (635.5 cu. ft).

A typical dogwood is an inverted cone, spreading 3.048 m. (10 ft.) at the top and 2.133 m. (7 ft.) high. The space occupied by each was 5.2 cu. m. (183.26 cu. ft.); for five it was 26 cu. m. (196.30 cu. ft.).

The four sandcherry shrubs were about equal to the willow, or .7 cu. m. (24.439 cu. ft.) × 4 equals 2.8 cu. m. (97.756 cu. ft.) total.

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[2] Approximations only.

The total space of shrubs was 47 cu. m. (1,649.57 cu. ft.); 47 cu. m. (1,649.57 cu. ft.) divided by 154 sq. m. (1,575 sq. ft.) equals approximately the average denseness to a depth of .31 meter (or 1 ft.).

### *c.* PINE TREE COVER

There were nine trees with crowns 4.6 m. (16 ft.) in diameter at the base and 8.5 m. (28 ft.) tall. The cone began 2.13 m. (7 ft. from the ground).

The space occupied by each tree cone was 46.7 cu. m. (1,649 cu. ft.). The total space of nine trees was 420.3 cu. m. (14,842 cu. ft.), which, divided by 154 sq. m., gives a depth of 2.8 m. (9.4 ft.).

## Animal Population

### *A.* FOR THE SEASON

#### 1. *Subterranean Stratum*

The animals of the subterranean stratum were not studied as systematically as those above ground.

The chief species are tiger-beetles and their larvae, Digger wasps, ants, and occasional white grubs and ground-beetle larvae. They were estimated, on the basis of considerable digging, at 100,000 per acre or 250,000 per hectare.

#### 2. *Ground and Lowest Herbs*

The factor for converting the counts secured by the bucket to numbers of animals per hectare is 207,800, and per acre is 84,000. The counts were made where the vegetation was sparse, and none were taken under heavier cover. General experience shows that increase occurs as vegetation increases, hence the population on the ground generally may be expected to have exceeded the numbers estimated below.

LIST I. *Number of animals in the ground stratum with lowest herbs. (Collected from 490 sq. cm.)*

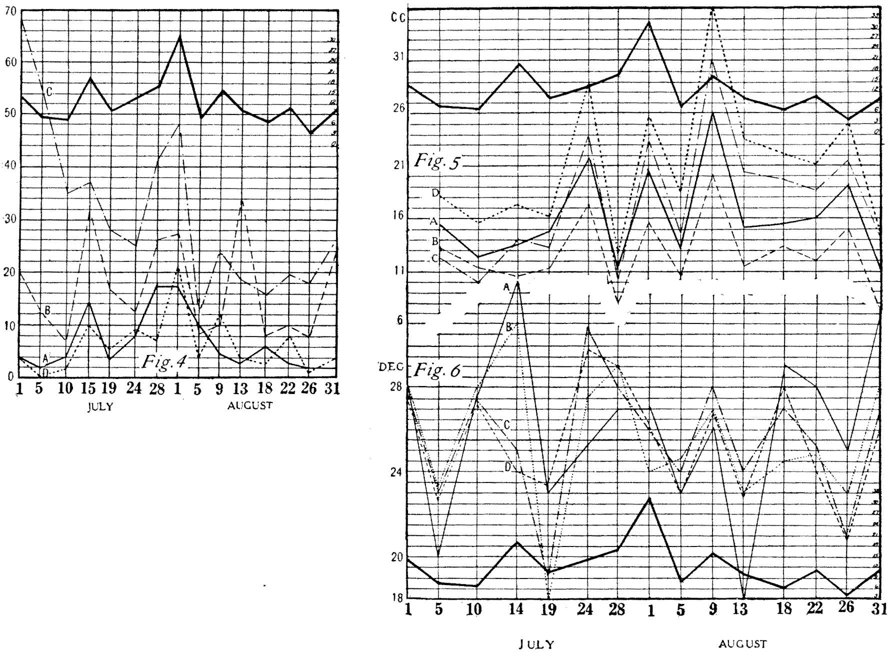
| Month | | | Total | Thousands of Individuals Per Hectare |
|---|---|---|---|---|
| July | 1 | 1 midge, 1 mosquito, 2 aphids | 4 | 830 |
| | 6 | 2 aphids | 2 | 415 |
| | 10 | 1 lepidopterous larva, 2 strawberry aphids, 1 insect egg | 4 | 830 |
| | 15 | 2 juvenile spiders, 11 aphids, 1 small fly | 14 | 2,909 |
| | 19 | 1 small spider, 1 small fly, 1 ant | 3 | 623 |
| | 24 | 4 aphids, 1 small spider, 2 lepidopterous larvae, 1 leafhopper | 8 | 1,662 |
| | 28 | 2 white scale insects, 9 aphids, 1 large ant, 1 small fly, 4 scales on strawberry petiole | 17 | 3,532 |
| Aug. | 1 | 17 strawberry aphids | 17 | 3,532 |
| | 5 | 3 ants, 6 aphids, 1 leafhopper | 10 | 2,078 |
| | 9 | 1 chrysomelid beetle, 3 aphids, 1 ant | 5 | 1,039 |
| | 13 | 1 ant, 1 leafhopper, 1 spider | 3 | 623 |
| | 18 | 6 strawberry aphids | 6 | 1,246 |

| | | | |
|---|---|---|---|
| 22 | 1 queen ant, 1 midge, 1 spider | 3 | 623 |
| 26 | 2 ants | 2 | 415 |
| 31 | 1 leafhopper, 1 ant | 2 | 415 |
| | Total | 100 | 20,772 |
| | Average | 6.6 | |
| | " Per Hectare | | 1,384 |
| | " Per Acre | | 560 |

### 3. *Population of the High Herb, Shrub, and Tree Strata*

The collections as given are 4 strokes of the sweep net, and are reduced to three strokes (the bucket equivalent) by multiplying by ¾.

*List 2. Herbs.*—The average height of the herbs on two thirds of the area is 45 cm. (18 in.), which would cover the total area 30 cm. high. The factor $(\frac{3}{4} \times \frac{2}{3} = \frac{1}{2})$ becomes $\frac{207,800}{2}$ or 103,900 for number per hectare (42,000 per acre).



FIGS. 4, 5, and 6. 4. Number of individuals taken at intervals of 4 or 5 days in the quantitative collections during July and August, 1914. *A,* from the ground (counted); B, from herbs; *C,* from shrubs; *D,* from trees; *B, C,* and *D,* with 4 sweeps of net. Heavy line shows total population in millions per hectare, with scale at right.

5. Evaporaton in c.c. per day, from readings at intervals of 4 or 5 days. *A,* on the ground; *B, C,* and *D,* at herb, shrub, and tree levels respectively. Heavy line same as in fig. 4.

6. Temperatures in degrees Centigrade, at same levels as in 5. Heavy line same as in 4.

Lists 2, 3 and 4: *Numbers of animals in the high herb, shrub and tree strata.*

| Date | List 2. Herbs | | List 3. Shrubs | | List 4. Trees | |
|---|---|---|---|---|---|---|
| | No. Col. | Thousands per Hectare | No. Col. | Thousands per Hectare | No. Col. | Thousands per Hectare |
| July 1 | 21 | 2,182 | 68 | 7,065 | 4 | 3,900 |
| 6 | 12 | 1,247 | 57 | 5,922 | 1 | 975 |
| 10 | 7 | 727 | 35 | 3,636 | 2 | 1,950 |
| 15 | 31 | 3,221 | 37 | 3,844 | 10 | 9,750 |
| 19 | 17 | 1,766 | 28 | 2,909 | 5 | 4,875 |
| 24 | 13 | 1,350 | 25 | 2,597 | 9 | 8,775 |
| 28 | 26 | 2,701 | 41 | 4,260 | 7 | 6,825 |
| Aug. 1 | 27 | 2,805 | 48 | 4,987 | 21 | 20,775 |
| 5 | 9 | 935 | 12 | 1,247 | 4 | 3,900 |
| 9 | 10 | 1,039 | 24 | 2,494 | 12 | 11,775 |
| 13 | 34 | 3,532 | 19 | 1,974 | 4 | 3,800 |
| 18 | 8 | 831 | 16 | 1,662 | 3 | 2,925 |
| 22 | 10 | 1,039 | 19 | 1,974 | 8 | 7,600 |
| 26 | 8 | 831 | 18 | 1,870 | 1 | 975 |
| 31 | 23 | 2,389 | 26 | 2,701 | 5 | 4,875 |
| Total | 256 | 26,595 | 473 | 49,142 | 96 | 93,675 |
| Average | 17 | | 31.5 | | 6.6 | |
| Per H | | 1,773 | | 3,274 | | 6,245 |
| Per A | | 717 | | 1,324 | | 2,528 |

*List 3. Shrubs.*—The average height of the shrubs equals the average height of the herbs; the factors are the same.

*List 4. Trees.*—The tree crowns cover the ground to an average depth of 2.9 m. (9 ft.). The hectare factor is 975,000 (acre, 395,000).

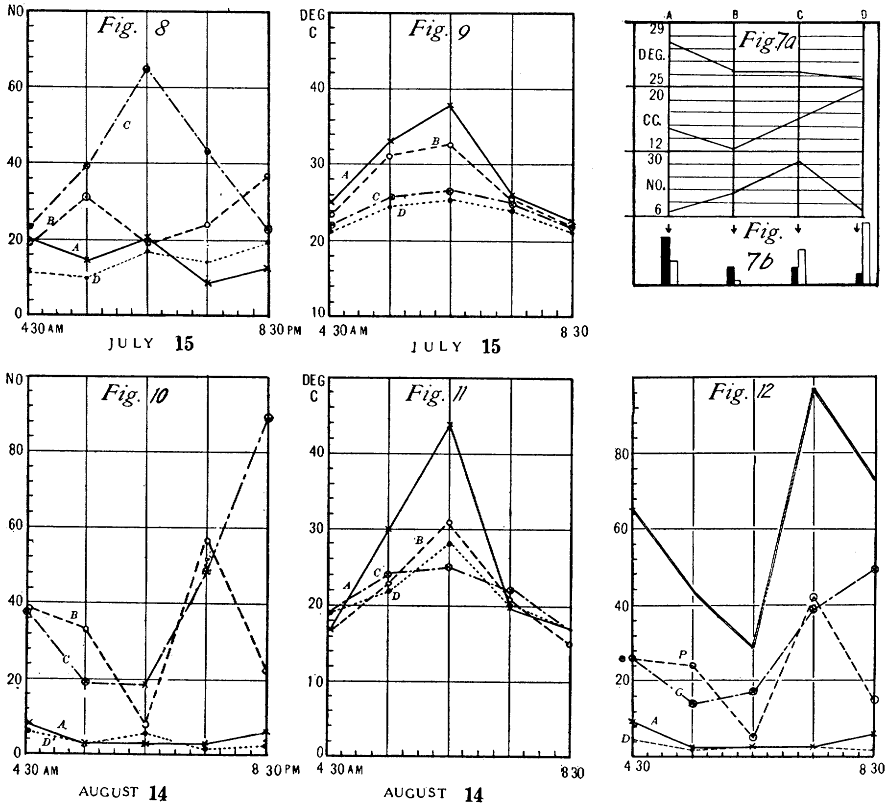
### 4. *Total Population*

The total estimated population varied greatly from day to day, as the table below indicates.

List 5. *Population in thousands of individuals on different dates.* (*Subterranean population omitted*)

| July | Thousands per Hectare | Aug. | Thousands per Hectare |
|---|---|---|---|
| 1 | 13,977 | 1 | 32,081 |
| 6 | 8,559 | 5 | 8,160 |
| 10 | 7,148 | 9 | 16,347 |
| 15 | 19,724 | 13 | 9,929 |
| 19 | 10,173 | 18 | 6,664 |
| 24 | 14,384 | 22 | 11,236 |
| 28 | 17,318 | 26 | 4,091 |
| | | 31 | 10,380 |

The mean population according to the above estimate is upwards of 12,600,000 per hectare, or approximately 5,000,000 per acre. McAttee found 1,216,880 per acre of forest floor and 13,654,710 per acre of meadow. Our largest estimate is 13,073,000 per acre on Aug. 1; including the subterranean forms Wolcott found on meadow (vacant city lots in central Illinois), on an average, for spring months, 3,600,000 per acre. His tables indicate that about 600,000 subterranean animals should be deducted to make the figures comparable. List 5 and the graphs of general population in figure 4 show that the mean population rose through July, reaching a maximum August 1, and



FIGS. 7*a*, 7*b*, 8, 9, 10, 11, and 12. 7*a*. Graph showing *mean* temperatures, *mean* evaporation rate, and *mean* of actual number of individuals collected for July and August, 1914; *A*, ground; *B*, herbs; *C*, shrubs; *D*, trees.

7*b*. Graphic comparison of average temperature and evaporation rates at the four levels. Black columns are temperature, white evaporation.

8. Quantitative collections for July 15, 1914. *A*, from the ground, actual quantity; *B*, *C*, and *D*, from herbs, shrubs and trees respectively (4 sweeps of net).

9. Temperatures on July 15, 1914. *A*, at ground, *B*, at herb level (16 inches above ground), *C*, at shrub level (5 feet above ground); *D*, at tree level (16 feet above ground).

10. Quantitative collections for August 14, 1914. *A*, *B*, *C*, and *D* as in 8.

11. Temperatures on August 14, 1914, *A*, *B*, *C*, and *D* as in 9.

12. Same as fig. 10, with the omission of species known to breed in water. Double line shows total number.

then falling off again through the month of August. With the exception of August 18, the collections were small when the temperature was low, and high when temperature was high. Roughly speaking, the same rise and fall is shown for temperature and evaporation.

### *B.* For Certain Days

#### 1. *Qualitative and Quantitative Details of Two Days' Collecting*

Collections were made every four hours throughout the day on July 15 and August 14, beginning at 4:30 A.M. and continuing to 8:30 P.M. (omitting 12:30 A.M.). The following lists and figures, inclusive, give the results of these observations:

List 6. *Collections made every four hours on July 15 and August 14.*

| Stratum Group and Hour 8:30 a. m. | | Date<br>July 15 No. | August 14 No. | Species Collected August 14 |
|---|---|---|---|---|
| Ground | Aphids (strawberry) | 14 | 9 | Aphididæ |
| | Flies | 3 | | |
| | Spiders | 3 | | |
| | Total | 20 | Total 9 | |
| Herbs | Ants | | 2 | *Lasius niger americanus* Emery |
| | Bugs | | 2 | *Balclutha impicta* V.D.<br>*Delphax* (sp) |
| | Flies | 7 | 4 | *Gonomyia sulphurella* O.S.<br>*Drosophila ampelophila* Loew.<br>*Sepsis cynipsea* Linn.<br>*Botanobia coxendix* Fitch |
| | Lacebug | 1 | 8 | *Corythuca marmorata* Uhl. |
| | Leafhoppers | 3 | 8 | *Empoasca mali* Le Baron<br>*Erythroneura vulnerata* Fitch<br>*Erythroneura comes vitis* Haec. |
| | Suiders | 3 | 3 | *Tetragnatha laboriosa* Htz.<br>*Clubiona abboti* Kock |
| | Total | 14 | Total 26 | |
| | *Aquatic Breeders* | | | |
| | Mosquitoes | 4 | 12 | *Culex* (sp.) |
| | Tree Frog | | 1 | *Hyla versicolor* Lec. |
| | Total | 4 | Total 13 | |
| | Total for the Stratum | 18 | 39 | |
| Shrubs | Bugs | 1 | 1 | *Lygus pratensis* Linn. |
| | Flies and midges | 10 | 4 | *Sapromyza tenuispina* Loew.<br>*Tanytarsus* sp.<br>*Sympycnus lineatus* Loew. |
| | Leafhoppers | 6 | 14 | *Empoasca mali* Le Baron<br>*E. obtusa* Walsh |

| Stratum Group and Hour 12:30 p. m. | | Date<br>July 15 No. | Date<br>August 14 No. | Species Collected August 14 |
|---|---|---|---|---|
| | Spiders | 1 | 1 | *Epeiridae* |
| | | | 1 | *Philodromus ornatus* Bks. |
| | | | 5 | *Macrochiles* sp. and young |
| | Total | 18 | Total 26 | |
| | *Aquatic Breeders* | | | *Culex* sp. |
| | Mosquitoes | 4 | 5 | *Ceratopogon peregrinus* Joh. |
| | Flies and Midges | | 5 | *Chrysotus picticornis* Loew. |
| | | | 2 | |
| | Tree Frog | 1 | | |
| | Total | 5 | Total 12 | |
| | Total for the Stratum | 23 | 38 | |
| Trees | Beetles | | 2 | *Cryptocephalus schreibersi* Suffr. |
| | Spiders | 3 | 3 | *Theridium spirale* Em. |
| | Total | 3 | Total 5 | |
| | *Aquatic Breeders* | | | |
| | Midges | 1 | 1 | *Chironomus decorus* Joh. |
| | Mosquiaoes | 7 | | |
| | Total | 8 | Total 1 | |
| | Total for the Stratum | 11 | 6 | |
| Grand total | for all strata | | | |
| | Without aquatics | 53 | 65 | |
| | With aquatics | 72 | 92 | |
| Ground | Aphids | 11 | | |
| | Ants | | 1 | *Lasius niger americanus* Emery |
| | Flies | 1 | | |
| | Leafhoppers | | 1 | *Empoasca mali* Le B. |
| | Spiders | 2 | 1 | *Philodromus* sp. |
| | Total | 14 | Total 3 | |
| Herbs | Aphids | 8 | | |
| | Ants | 7 | 3 | *Lasius niger americanus* Emery |
| | Flies, etc. | 14 | 17 | *Drosophila adusta* Loew.<br>*Leptocera fontinalis* Fall. |
| | Leafhoppers | 1 | 4 | *Cicadula 6-notata* Fall.<br>*Empoasca mali* Le Baron<br>*Empoasca obtusa* Walsh<br>*Gypona 8-lineata* Say |
| | Spiders | 1 | | |
| | Total | 31 | 24 | |
| | *Aquatic Breeders* | | | |
| | Fly | | 4 | *Tanytarsus* sp. |
| | Midge | | 6 | *Ceratopogon fusculus* Coq. |
| | | | 10 | |
| | Total for Stratum | 31 | 34 | |

| Stratum Group and Hour 4:30 p.m. | | Date | | |
|---|---|---|---|---|
| | | July 15 No. | August 14 No. | Species Collected August 14 |
| Shrubs | Flies, etc. | 24 | 6 | *Chrysotus picticornis* Loew.<br>*Drosophila ampelophila* Loew.<br>*Gonomyia sulphurella* O.S. |
| | Leafhoppers | 10 | 7 | *Cicadula 6-notata* Fall.<br>*Empoasca mali* Le Baron<br>*Empoasca obtusa* Walsh<br>*Gypona 8-lineata* Say |
| | Caterpillar | | 1 | unidentified |
| | Spiders | 3 | 1 | *Tetragnatha laboriosa* Htz. |
| | Total | 37 | Total 14 | |
| | *Aquatic Breeders* | | | |
| | Midges | 0 | 2 | *Ceratopogon peregrinus* Joh.<br>*Chironomus festivus* Say |
| | Mosquitoes | 0 | 2 | *Culex* sp. |
| | Caddice Fly | 0 | 1 | |
| | | 0 | 5 | |
| | Total for Stratum | 37 | 19 | |
| Trees | Beetles | | 2 | *Cryptocephalus schreibersi* Suffr.<br>*Dicerca punctulata* Schön. |
| | Flies | 7 | | |
| | Spiders | 3 | | |
| | Total for Stratum | 10 | 2 | |
| Total for all Strata | | | | |
| | Without aquatics | 92 | 43 | |
| | With aquatics | 92 | 58 | |
| Ground | Ants | 1 | | |
| | Aphides | 17 | | |
| | Beetles | 1 | | |
| | Cricket | | 1 | *Ellipes minutus* Scudd. |
| | Flies | 1 | | |
| | Spiders | | 2 | *Dendryphantes octavus* Hentz |
| | Total | 20 | Total 3 | |
| Herbs | Ants | 3 | 1 | *Lasius niger americanus* Emery |
| | Flies, etc. | 8 | 2 | *Chrysotus picticornis* Loew. |
| | Leafhoppers | 1 | 2 | *Cicadula 6-notata* Fall.<br>*Empoasca mali* Le Baron |
| | Moth and larva | 2 | | |
| | Spiders | 4 | | |
| | Total | 18 | Total 5 | |
| Shrubs | Beetle | 1 | | |
| | Flies and midges, etc. | 38 | 8 | *Drosophila ampelophila* Loew.<br>*Gonomyia sulphurella* O.S. |

| Stratum Group and Hour 8: 30 p. m. | | Date | | |
|---|---|---|---|---|
| | | July 15 No. | August 14 No. | Species Collected August 14 |
| | Damsel fly | 1 | | |
| | Leafhoppers | 4 | 5 | *Empoasca obtusa* Walsh<br>*Gypona 8-lineata* Say |
| | Moths and larva | 2 | | |
| | Spiders | 5 | 3 | *Dendryphantes octavus* Hentz<br>*Maevia vittata* Hentz-*niger* Hentz<br>*Thiodina* sp. |
| | Total | 51 | Total 17 | |
| | *Aquatic Breeders* | | | *Culex* sp. |
| | Mosquitoes | 14 | 2 | |
| | Total for the Stratum | 65 | 19 | |
| Trees | Flies and midges | 9 | | |
| | Lacebug | 1 | | |
| | Moth | 2 | | |
| | Spiders | | 3 | *Epeira* (very young) |
| | Total | 5 | Total 3 | |
| | *Aquatic Breeders* | | | |
| | Mosquitoes | 5 | 0 | |
| | Midges | 0 | 1 | *Chironomus fulvus* Joh. |
| | Total | 5 | Total 1 | |
| | Total for the Stratum | 17 | 4 | |
| | Grand Total All Strata | | | |
| | Without aquatics | 102 | 28 | |
| | With aquatics | 121 | 31 | |
| Ground | Aphids | 4 | | |
| | Ants | 2 | | |
| | Beetles | | 1 | *Stenolophus ochropezus* Say |
| | Bugs | | 2 | Jassidae |
| | Spiders | 2 | | |
| | Total | 8 | Total 3 | |
| Herbs | Ants | 7 | 3 | *Lasius* sp. |
| | Bugs | 3 | 6 | Jassidae<br>*Erythroneura tricincta* Fitch<br>*Corythuca marmorata* Uhl.<br>*Dikraneura abnormis* Walsh |
| | Flies, etc. | 10 | 42 | *Drosophila ampelophila* Loew.<br>*Drosophila adusta* Loew.<br>*Drosophila amoena* Loew.<br>*Drosophila obesa* Loew.<br>*Leptocera fontinalis* Fall.<br>*Schoenomyza* sp.<br>*Sepsis cynipsea* Linn. |

| Stratum Group and Hour 8: 30 p. m. | | Date | | Species Collected August 14 |
|---|---|---|---|---|
| | | July 15 No. | August 14 No. | |
| | Mosquitoes | 2 | | |
| | Spiders | 2 | 2 | *Philodromus,* young |
| | Total | 22 | Total 42 | |
| | *Aquatic Breeders* | | | |
| | Mosquitoes | 2 | 2 | *Culex* sp. |
| | Midges | 0 | 4 | *Chironomus* sp.<br>*Ceratopogon fusculus* Coq. |
| | Flies | 0 | 7 | *Tanypus monilis* Linn.<br>*Sympycnus lineatus* Loew. |
| | | 2 | 13 | |
| | Total for the Stratum | 24 | 55 | |
| Shrubs | Ants | | 4 | *Lasius niger americanus* Emery |
| | Bugs | 4 | 14 | *Empoasca mali* Le Baron<br>*Gypona 8-lineata* Say |
| | Flies, etc. | 37 | 24 | *Aphiochaeta* sp.<br>*Discocerina* sp.<br>*Drosophila obesa* Loew.<br>*Gonomyia sulphurella* O.-S.<br>*Leptocera fontinalis* Fall. |
| | Spiders | | 4 | *Philodromus ornatus* Banks young |
| | Total | 41 | Total 39 | |
| | *Aquatic Breeders* | | | |
| | Mosquitoes | 3 | 3 | *Culex* sp. |
| | Midges | 0 | 7 | *Chironomus* (*modestus*)<br>*Ceratopogon fusculus* Coq.<br>*Chironomus fulvus* Joh. |
| | | 3 | 10 | |
| | Total for the Stratum | 44 | 49 | |
| Trees | Beetles | | 1 | *Diabrotica 12-punctata* Fabr. |
| | Flies | 8 | | |
| | Spiders | 4 | 2 | *Epeira* sp.<br>*Theridium spirale* Em. |
| | *Aquatic Breeders* | | | |
| | Mosquitoes | 6 | | |
| | Total for the Stratum | 14 | 3 | |
| | Grand total for All Strata | | | |
| | Without aquatics | 83 | 87 | |
| | With aquatics | 94 | 110 | |

| Stratum Group and Hour 8: 30 p. m. | | Date | | |
|---|---|---|---|---|
| | | July 15 No. | August 14 No. | Species Collected August 14 |
| Ground | Aphids | 11 | | |
| | Beetles and larva | 2 | 2 | *Cardiophorus,* larva |
| | Flies | | 4 | *Leptocera fontinalis* Fall. |
| | Total | 13 | Total 6 | |
| Herbs | Beetle (Chrysomelid) | 1 | | |
| | Flies, etc. | 35 | 12 | *Drosophila obesa* Loew. |
| | Leafhoppers | 1 | 2 | *Erythroneura comes vitis* Harris<br>*Erythroneura vulnerata* Fitch |
| | Spiders | | 1 | |
| | Total | 37 | Total 15 | *Theridium spirale* Emerton |
| | *Aquatic Breeders* | | | |
| | Mosquitoes | | 8 | *Culex* sp. |
| | Total for the Stratum | 37 | 23 | |
| Shrubs | Beetle (Chrysomelid | 7 | | |
| | Flies, etc. | 13 | 26 | *Bezzia setulosa* Loew.<br>*Drosophila amoena* Loew.<br>*Drosophila obesa* Loew. |
| | Leafhoppers | 3 | 24 | *Erythroneura comes vitis* Harris |
| | Total | 23 | Total 49 | |
| | *Aquatic Breeders* | | | |
| | Mosquitoes | 2 | 39 | *Culex* sp. |
| | Total for the Stratum | 25 | Total 89 | |
| Trees | Ants | 3 | | |
| | Flies, etc. | 3 | 1 | *Drosophila obesa* Loew |
| | Leafhoppers | | 1 | *Erythroneura comes vitis* Harris |
| | Spiders (Young) | 9 | | |
| | Total | 15 | 2 | |
| | *Aquatic Breeders* | | | |
| | Mosquitoes | 4 | 2 | *Culex* sp. |
| | Total for the Stratum | 19 | 4 | |
| | Total all Strata | | | |
| | Without aquatics | 88 | 73 | |
| | With aquatics | 94 | 122 | |

## Migration

A study of the lists and of figures 7 to 11 show that a migration of aquatic species into the land habitats occurred at different hours on the two dates when collections were made. On July 15 the total at noon was increased by the influx of mosquitoes, while on August 14 the total at 8:30 P.M. was increased by the influx of aquatic breeders from other habitats. However, even the complete listing and identification of August 14 does not show consistent totals. It appears that animals are in an easier position to be captured under certain conditions than under others. These conditions fall at different times of day due to weather, etc. For example, at the time of the morning collection of August 14 the vegetation was wet in consequence of a heavy shower the day before. This moisture partially equalized the humidity and rate of evaporation at the different levels. The results are different from those obtained July 15.

The most convincing evidence of migration of animals from one level to another as conditions change is that obtained from observation of species. The table for August 14 gives much interesting data. The following cases of apparent migration are found:

Among the spiders, *Tetragnatha laboriosa* was in the herbs 4:30 A.M., and shrubs 8:30 A.M.; *Theridium spirale,* in the trees 4:30 P.M., and herbs 8:30 P.M.

For the insects, apparent migrations shrubwise during the day are *Botanobia coxendix, Culex* sp., *Erythroneura comes vitis, Drosophila ampelophila,* herbs to shrubs; *Chironomus fulvus,* trees to shrubs; *Lasius niger americanus,* ground and herbs to herbs and shrubs; *Drosophila amoena,* herbs to shrubs.

Evidences of migrations late in the day downward to lower levels are *Drosophila ampelophila,* shrubs to herbs, and *Leptocera fontinalis,* shrubs to ground.

In quantity as well as quality the movement seems to be shrubwise during the early day and downward at night. The shrubs show not only the greater number of individuals, but also the greater number of species.

The total number of different species at various levels are as follows:

| | | | |
|---|---|---|---|
| Ground...... | 10 species, | average temperature 25.4°, | range 25° |
| Herbs....... | 34 species, | average temperature 21.2°, | range 16° |
| Shrubs....... | 38 species, | average temperature 21.0°, | range 8° |
| Trees........ | 11 species, | average temperature 21.2°, | range 11° |

In terms of temperature, these results are not a coincidence; the greater number of species is to be found at the level where changes in temperature are least and, possibly, also where the temperature itself is medium compared to the other levels.

Horizontal migrations may account for the fluctuations of numbers of individuals of given species. Of the leaf hoppers, *Erythroneura comes vitis* was taken as follows August 14: At 4:30 A.M., 1 specimen; at 8:30 A.M., at 12:30 P.M., and at 4:30 P.M., no specimen; and at 8:30 P.M., 27 specimens. No doubt an inwards migration of this insect occurred toward nightfall. The influx of aquatic animals suggests the importance of checking against horizontal migrations in quantitative study.

## Discussion and Summary

The following indicate the difficulties and matters to be taken into account in quantitative work:

1. The animal population rose during July, reached a maximum about August 1, and then declined.
2. The number of animals varied in a general way directly with temperature and evaporation.
3. The number of animals in the area studied was increased by influx from adjacent habitats, especially by water-breeding species from the near-by swamp.
4. Some animals migrate upward during the first half of the day and downward during the later portion.
5. The number of species and individuals is greatest in the shrubs.
6. The accessibility of animals varies with conditions and makes collections with nets, etc., variable.

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